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SUMMARY

The current policy in the Netherlands is that rents in the social housing sector are regulated and do not reflect market conditions. Housing associations are studying the possibility to partly adjust rents to the market rent, or at least they want to have insight in the size of the implicit subsidy they provide to the tenant. Market rents cannot easily derived from a hedonic price model, because the non-regulated rental market is very small, so market rents are hardly available. In this paper an alternative method of determining 'market rents' is presented, based on the number of reactions, i.e. persons that showed interest in a house conditional on the non-negotiable asking rent. When the number of reactions is relatively high, it is assumed that the fixed asking rent is lower than the market rent, and vice versa. In this model the number of reactions is explained by the rent price, the transaction date, the house value and additional variables controlling for the quality of the house, where the house value is the yearly appraised value used for property tax. The market rent is defined such that the probability of not renting the house is small, say 5%. Rents can be adjusted based on the outcomes of the model, such that the probability of not renting the house is 5%. Results are presented for different regions in the Netherlands, based on a large database containing rents, values and reactions. The results are compared to market rents that are calculated from a user cost approach.

Keywords: Social housing, User Cost.

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1 Introduction

Housing associations in the Netherlands have the social task of providing affordable housing for those who are unable to find a dwelling in the market. Housing associations are non-profit organizations which are required to operate in the interest of housing. Their share in the total Dutch housing stock is approximately one third. A description of the Dutch social housing system is provided by Aedes (2007). The private rental sector is relatively small, approximately 10% of the housing stock. The rents in the social sector are highly regulated by the government. Rent control covers 95% of all rented houses, including those from commercial landlords.

One of these regulations is that rents may not exceed the maximum reasonable rent, which is a rent depending on a house value rating system[1]. This house value rating system controls for housing and neighborhood characteristics, but has no relation with market values in the owner-occupied sector. As a consequence the rents in tight market areas, such as the main cities in the Randstad area (especially Amsterdam and Utrecht) are relatively low compared to transaction prices, see for example Boelhouwer and Hoekstra (2009).

Housing associations are more and more interested in knowing the market rents of their housing stock. This may seem to be in contrast with their social task, but there is a number of reasons for this interest. The first reason is that for a part of their housing stock[2] there are no restrictions on the rent level. For these houses there is no apparent reason not to ask the market rent. Moreover, there is an ongoing administrative and political debate about liberalization of a part of the social housing sector. A second reason is that the actual rent may be lower than the maximum reasonable rent, providing room for rent increases in the case the market rent is higher than the actual rent. A final reason is that housing associations want to know the amount of implicit subsidy they provide by asking the actual rent instead of the market rent. Conijn and Schilder (2009) show on an aggregate level that for housing associations the average market value of a house is approximately €151,000, while the reported tenanted investment value is no more than €33,000. They show that a major part of this value gap can be explained by rent control.

The focus of this paper is the determination of the market rent for individual houses. The problem is that the commercial residential rental market is relatively small, approximately ten percent of the total housing stock of seven million houses. An additional problem is that house rents are not centrally registered and that rents from commercial landlords are not publicly available. As a consequence it is not possible to apply a hedonic price model for the determination of the market rent.

An alternative is to compute the imputed rent by the user cost approach, where the imputed rent depends on the market value in the owner-occupied sector, see for example Hendershott and Slemrod (1983), Poterba (1984, 1992), Conijn (1995), Haffner (2000) and Himmelberg et al. (2005). The imputed rent is considered as the market rent and can be calculated from the WOZ value[3], a yearly assessed value for the property tax. The valuation fictions of the law WOZ are that full and unencumbered ownership is transferred and the buyer can take possession of that immediately and completely. It can be defined as the market value in the owner-occupied sector.

In this paper an alternative, and as far as we know, new method is presented to calculate market rents by modeling the number of reactions, persons (households) that showed interest in a specific rental house, given a non-negotiable rent. Contrary to the user cost approach it is more focused on the demand side of the rental residential market. The user cost approach employs selling prices from the owner-occupied sector to derive market rents, often not widely available in areas with a majority of social housing. In the reaction model additional demand information from within the rental residential sector is used, namely the number of reactions. Before explaining the alternative method, a short description of the current housing distribution system for the social rental sector is provided.

The social housing associations have the task of providing accommodation to people with lower incomes and other special attention groups (for example students, elderly, and people with medical and social prob-

[1]This rating system is called Woning Waarderingsstelsel (WWS). The system consists of allocating points (value units) to different qualities and amenities of a dwelling, such as surface of the rooms including bathrooms and kitchens, size of other spaces, central heating, insulation, size of kitchen sink, sanitary facilities, facilities for physical handicaps, private external spaces (balconies and gardens), type of dwelling, locational aspects of the dwelling (including vicinity of public green spaces, play facilities, parking facilities, schools, shops, etc.), inconvenient circumstances (such as noise hindrance, serious dereliction of the neighborhood, soil- and air pollution), and services offered in the dwelling (such as alarm installation, provision of meals by the landlord, use of recreational rooms). See for more details the website of the Ministry of Housing, Spatial Planning and the Environment, www.vrom.nl.

[2] All houses with 143 or more points in the rating system. These are the more spacious higher quality houses.

[3] "Waardering Onroerende Zaken" (WOZ) is literally translated by Assessment of Real Estate.

lems). To qualify for a home you have to meet certain criteria and register. Registration normally costs a one-off fee, about €60. Housing associations advertise periodically (every two weeks) homes that have become available for rent on the web and in a magazine.[4] Relevant information is provided for each home, including location, floor area, type of home, number of rooms, and the rent. If you find a suitable home you can register for it.[5] Your chance of getting the home depends on the popularity of the home, the period that you have been registered (or the period that you have already occupied a home). The order of allocation is determined by the length of the occupancy period (in case of transferees) or the registered period (in case of starters). The person with the highest priority has the right to rent the house for the non-negotiable rent. If he does not want to rent, the second one on the ranking list has the right to rent, and so on. There is no penalty for not accepting a house. It is allowed to register for up to three houses each term (normally every two weeks). For the Amsterdam region it normally takes more than 5 years to find a suitable home. In the city center the waiting time is much longer (> 10 years).

In the reaction model we model the number of reactions, persons or households that showed interest in a specific house. When the number of reactions is relatively high, it is assumed that the non-negotiable rent is lower than the market rent, and vice versa. In the reaction model the number of reactions is explained by the rent level, the transaction date, the house value (WOZ value) and additional variables controlling for the quality of the house and the neighborhood. The market rent is defined such that the probability of not renting the house is small, say 5%. An operational definition is that the expected number of reactions must be larger than q_a. q_a is the 95% quantile of 'acceptance', that is the number of persons that rejected the house plus 1, the person that accepted the house. Market rents can be calculated from the outcomes of the reaction model and the 95% quantile of 'acceptance', such that the probability of not renting the house is 5%.

The reaction model will be applied on the housing stock of the housing association "De Alliantie", which operates in 4 different regions in the western part of the Netherlands.[6] The total number of houses is almost 58,000. The market rents following from the reaction model will be compared to the outcomes of the user cost approach.

The paper proceeds as follows. Section 2 gives the general concept of the reaction model. Section 3 describes the user cost approach and provides the assumptions on the input parameters, such as discount rate, marginal tax rate and maintenance. Next, Section 4 gives a description of the data. In the period 2005 to 2007 almost 7,100 houses changed from tenants. This is approximately 12% of the housing stock of the housing association. For these houses the rents, the number of reactions and acceptance, and additional variables for controlling the quality of the house are available. Section 5 provides the estimation results from the reaction model for the 4 different regions, based on a total number of 7,100 observations. The reaction model is specified as a random effects model, where the random effects are provided by neighborhoods. Next, the estimation results are used to calculate market rents for more than 90% of the total housing stock, for which the relevant variables are available. Finally, the market rents that are derived from the reaction model are compared to market rents calculated by the user cost approach. Section 6 concludes.

[4] Woningnet (www.woningnet.nl) combines the house supply of housing associations in different housing markets.

[5] Some criteria apply with respect to the ratio between income and rent level, and the number of persons in the household compared to the house size.

[6] "De Alliantie" is one of the larger housing associations in the Netherlands. In the 4 regions other (large) housing associations are active as well.

2 Reaction Model

In this Section the reaction model will be presented. As far as we know this method has not previously been applied to derive market rents. In the reaction model information from the housing distribution system, as described in the previous Section, is used to calculate market rents. This information contains for each house that had a tenant change:

- Y: the number of reactions
  the number of persons that showed interest in the house by registering;
- A: the acceptance
  the rank number of the person that was willing to rent the house;
- R: the rent level;
- V: the value of the house;
- x: characteristics of the house.

The people that are interested in a house and register for it, are ranked according to their waiting time. The waiting time equals the length of the occupancy period (in case of transferees) or the registered period (in case of starters). The person with the highest priority has the right to rent the house for the non-negotiable rent. If he does not want to rent, the second one on the ranking list has the right to rent, and so on.

A sensible definition of market rent is a rent such that the house will not be rented with at most probability α, say 5%. The probability of renting a house depends on the number of reactions and acceptance, where the acceptance is the number of persons who had the right to rent the house, but rejected, plus the person that accepted the house. The higher the number of reactions is, the higher the probability that someone accepts the house. We assume that the probability that the number of reactions is equal to n, depend on the rent level (R), the value (V), and the other characteristics of the house (x), so

$$p_Y(n) \equiv P(Y = n|R, V, x), \tag{2.1}$$

where P denotes a probability function. A house will not be rented when the number of rejections equals the number of reactions, denoted by $Y = n$ and $A = n + 1$. If it is assumed that the probability that an individual accepts a house, does not depend on the number of of reactions (Y), the rent level (R), the assessed value (V) and other characteristics (x), the conditional (on the number of reactions) probability can be written as $P(A = n + 1|Y = n) = (1 - p)^n$ where p is the probability that a person accepts a house to rent. The unconditional probability of not renting a house is given by

$$P(\text{No rent}) = \sum_{n=1}^{\infty} [P(A = n + 1|Y = n) \times P(Y = n)] = \sum_{n=1}^{\infty} [(1 - p)^n \times p_Y(n)]. \tag{2.2}$$

It is assumed that the probability $p_Y(n)$ decreases when the rent level (R) is increased, keeping the other variables constant. The market rent is the rent for which it holds that the probability of not renting a house equals α, so $P(\text{No rent}) = \alpha$.

In the reaction model we will model the number of reactions as a function of the rent level, the value, and the other characteristics, corresponding to Eq. (2.1). We will use a simplified version of Eq. (2.2) to derive the market rent. We define the market rent as the rent where with a probability $(1 - \alpha)$ the number of reactions must exceed a certain threshold, say q_A. The value of q_A is the $(1-\alpha)$ quantile of the unconditional distribution from the acceptance (A), $q_A = q(A; 1 - \alpha)$. It is assumed that the threshold value q_A is equal for all houses, independent of the number of reactions (Y), the value of the house (V) and other characteristics (x).

The basic (time invariant) specification of the reaction model is provided by

$$y_i = r_i\delta + v_i\theta + x_i'\beta + \varepsilon_i, \quad i = 1, \ldots, N, \quad \varepsilon_i \sim N(0, \sigma^2), \tag{2.3}$$

where y_i is the log of the number of reactions for house i, x_i is a vector of house characteristics including the house value with coefficient vector β, r_i is the log housing rent with coefficient δ, v_i is the log value with coefficient θ, and N is the number of observations. A large (small) number of reactions (Y) is expected when the rent level (R) is low (high) in comparison to the value of the house (V), implying a negative sign for the coefficient δ. We expect that the coefficient θ for the value of the house is positive, reflecting that a higher quality of the house results in a higher expected number of reaction.

We choose specification (2.3) partly because of the mathematical convenience. The log-log specification ensures that the coefficients δ and θ can be interpreted as elasticities. We use the log of the number of reactions as dependent variable to ensure that the modeled number of reactions is non-negative. A motivation for using the log of the rent and value is that a priori the relation between not assumed to be linear. A statistical motivation for the log-log specification is that the distribution of the residuals is closer to normality, in line with one of the standard assumptions –normality of the error term– when doing inference in a linear model. In Section 5 we will slightly adapt the specification of the reaction model to deal with time and location. Fixed time effects and random neighborhood effects will be added to Eq. (2.3), but this does not change the general structure of the model.

Rents will be adjusted such that the probability of renting a house is the same for each house. In the rent adjustment two distinct effects are distinguished, a *redistribution* and a *level* effect. The redistribution effect changes the rents, such that the expected number of reactions must be the same for every house (condition 1) and the average (log) rent level remains the same (condition 2). On the other hand the level effect is a general rent increase or decrease.

The adjusted rent corresponding to the *redistribution* effect can be expressed as

$$r_i^* = \frac{\bar{y} - v_i\theta - x_i'\beta}{\delta}, \tag{2.4}$$

where $\bar{y} = N^{-1}\sum_{i=1}^{N} y_i$. Substituting for r_i the adjusted rent in Eq. (2.3) gives

$$y_i^* = \bar{y} + \varepsilon_i, \tag{2.5}$$

showing that for every house the expected number of reactions is equal to $\bar{y}$, meeting the first condition. The second condition can easily be verified by expressing Eq. (2.3) as $r_i = (y_i - v_i\theta - x_i'\beta - \varepsilon_i)/\delta$, showing that $E[\bar{r^*}] = E[\bar{r}]$. Note that the redistribution effect does not depend on q_a.

The *level* effect depends on the log number of reactions q_a, that is needed to rent the house with a probability of $(1-\alpha)$. In the case the α quantile of y^* denoted by $q(y^*;\alpha)$ is bigger than q_a, the rents has to be increased to reduce the number of reactions (and vice versa). The level effect in the number of reactions is $q(y^*;\alpha) - q_a$. This is illustrated by Figure 2.1. The solid line is the density of the (log) number of reactions (y^*), in this fictitious example assumed to be normally distributed. The 5% quantile of y^* is equal to 3.93, larger than the threshold $q_a = 3.46$. The dashed line is the density of the shifted (log) number of reactions, such that the 5% quantile of y^* is equal to q_a. The level effect is the shift in the expected number of reactions from 4.63 to 4.63-0.47=4.16.

The rent increase that results from the level effect is equal to $-(q(y^*;\alpha) - q_a)/\delta$, note that $\delta < 0$. The market rent (mr) is then provided by

$$\text{mr}_i = \frac{\bar{y} - v_i\theta - x_i'\beta - (q(y^*;0.05) - q_a)}{\delta}. \tag{2.6}$$

The quantile $q(y^*;\alpha)$ can be either calculated from the predicted values $\hat{y}_i$, or directly from $\Phi^{-1}(\alpha\sigma + \bar{y})$, where $\Phi^{-1}(p)$ denotes inverse standard normal cumulative distribution function.

In this approach it is assumed that the coefficients $(\delta, \theta, \beta, \sigma)$ in Eq. (2.3) remain the same in case of a rent adjustment. This is a reasonable assumption for small and moderate rent adjustments, but this assumption may not be valid in case of an extraordinary rent increase (decrease).

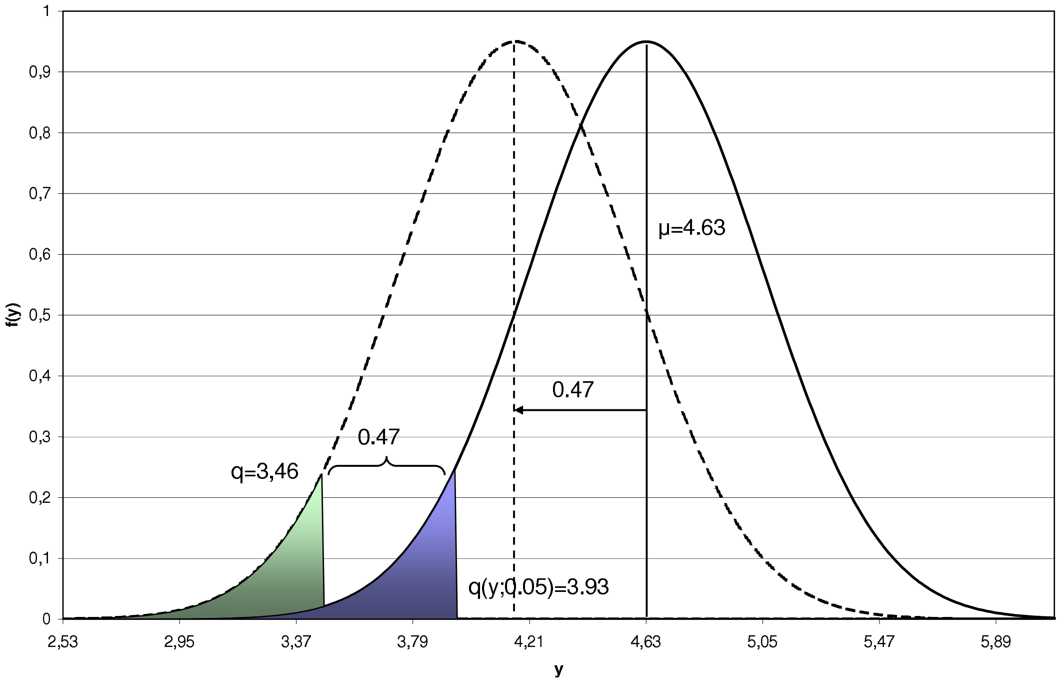

Figure 2.1: Level effect.

3 The user cost approach

3.1 User cost

This section describes the more common user cost approach to derive market rents. The annual cost of ownership, also known as the imputed rent, is the sum of different components representing costs and offsetting benefits. Some references are Hendershott and Slemrod (1983), and Poterba (1984, 1992). The annual cost of ownership in percentage of the value is referred to as the user cost. The user cost can be derived from two equations (Conijn, 1995; Haffner, 2000),

$$V_t = \sum_{s=t+1}^{T} \frac{\text{CIF}_s - \text{COF}_s}{(1+r)^{s-t}} + \frac{V_T}{(1+r)^{T-t}}, \quad (3.1)$$

$$\Delta V_{t+1} = (g_{t+1} - d_{t+1})V_t, \quad (3.2)$$

where V_t is the value of the house at time t, r is the discount rate, and CIF_t and COF_t are the cash inflow and cash outflaw at time t, respectively.

The first equation states that the present value of the investment good ‘house’ is equal to the sum of the discounted difference between future cash inflows and outflows, plus the discounted terminal value V_T.

In the second equation the value increase (or decrease) is defined as the difference between the price inflation ($g_{t+1}V_t$) and the depreciation ($d_{t+1}V_t$), where both d_{t+1} and g_{t+1} are in percentages of the value at time t. The price inflation g_t is the price change of a constant-quality house.

The cash inflow (CIF_{t+1}) can be derived from Eqs. (3.1) and (3.2). It follows from Eq. (3.1) that $\text{CIF}_{t+1} = rV_t - \Delta V_{t+1} + \text{COF}_{t+1}$, by substituting T by $t + 1$. Substituting Eq. (3.2) in the preceding equation provides the cash inflow or the annual user cost of housing,

$$\text{UC}_t = \text{CIF}_t = rV_{t-1} + \text{COF}_t + d_t V_{t-1} - g_t V_{t-1}. \quad (3.3)$$

The costs of using the houses equals the income accruing to the investor. The content of the cash outflow COF_t is country specific (for example with respect to tax payments and interest deductibility) and will be specified in more detail in the next subsection.

In equilibrium the expected annual costs of owning a house must equal the annual cost of renting (R), so

$$R_t = \text{UC}_t = u_t V_{t-1}, \quad (3.4)$$

where the fraction u_t is known as the (percentage) user cost of housing, see for example Himmelberg et al. (2005).

3.2 Implementation

In order to obtain market rents we will implement in this subsection the user cost approach for the housing market in the Netherlands. We slightly adapt the identity in Eq. (3.4) to a multi-period version,

$$\sum_{t=1}^{n} \frac{R_t}{(1+r)^t} = \sum_{t=1}^{n} \frac{\text{UC}_t}{(1+r)^t}. \quad (3.5)$$

It is assumed that the discounted value of future rents is equal to the discounted value of future costs of housing, so the user cost depends on the time horizon n, that is the expected occupancy duration.

The reason for this change is that only the initial rent, the rent when the tenant changes, can be set. The subsequent rent increases follow the consumer price index,

$$R_t = (1+p) \times R_{t-1}, \quad (3.6)$$

for $t = 1, \ldots, n$, where p is the price inflation measured by the consumer price index. The left-hand side of Eq. (3.5) can be formulated as

$$\sum_{t=1}^{n} \frac{R_t}{(1+r)^t} = R_0 \sum_{t=1}^{n} \left(\frac{1+p}{1+r}\right)^t. \quad (3.7)$$

For the calculation of the user cost UC_t we make a couple of additional assumptions:

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1. The expected yearly return on the market value V for a constant-quality house is equal to $g_t = p + r_V$, where p is the consumer price inflation,

$$V_t = (1 + p + r_V) \times V_{t-1}. \tag{3.8}$$

This equation differs from Eq. (3.2) as the depreciation (d_t) is not included. It is assumed that the maintenance costs d^*, part of the cash outflow, keep the property up-to-date.
2. The purchase of the house is fully financed by a mortgage debt (D_0), including the transaction costs (tc), to take maximal advantage of the interest deductibility, so

$$D_0 = V_0 \times (1 + \text{tc}). \tag{3.9}$$

Apart from fees for the notary, Land Registry and mortgage providers, a transfer tax (6% of the house value) will be charged. The total transaction costs are approximately 10% of the house value. The impact of the transactions costs on the user costs will be large (small) when the occupancy duration (n) is short (long).
3. For mathematical convenience it is assumed that the debt D_t increases each period with the same percentage (ir),

$$D_t = D_{t-1} \times (1 + \text{ir}), \tag{3.10}$$

such that in expectations the final debt D_n equals the final value of the house V_n. It follows that ir $= (1 + p + r_V)/(1 + tc)^{1/n} - 1$. The debt increase ΔD_t can be considered as the capital gain, replacing the term $g_t V_{t-1}$ in Eq. (3.3).[7]

We now look in more detail on the components of UC_t in Eq. (3.3). The cash outflow (COF_t) consists of 1) property tax (pt) and 2) tax on imputed rent (tir), where the taxes depend on the value in the preceding period, and 3) payments for insurance costs and maintenance, including major repairs d^*. UC_t can be re-expressed as

$$\text{UC}_t = r(1 - \text{mt})D_{t-1} + (d^* + \text{tir} + \text{pt})V_{t-1} - \Delta D_t, \tag{3.11}$$

D_{t-1} is the debt in the preceding period, and mt is the marginal tax rate. Interest payments are deductible from income tax, where the marginal tax rate progressively depends on the height of the income. It is assumed that the ratio between the value and the income equals 4.5.[8] ΔD_t is the increase in debt, replacing the capital gain $g_t V_{t-1}$. Each component of the user cost (UC_t) can be expressed in terms of the initial value V_0.

We now can define the (percentage) user cost as $u^n = R_0/V_0$. After some manipulations it follows from Eqs. (3.5) and (3.7)–(3.11) that the percentage user cost $u^n = R_0/V_0$ can be expressed as

$$\begin{aligned} u^n &= \frac{d^* + \text{tir}(1 - \text{mt}) + \text{pt}}{1 + p + r_V} \times \sum_{t=1}^{n} \left(\frac{1 + p + r_V}{1 + r} \right)^t \\ &+ (1 + \text{tc}) \frac{r(1 - \text{mt}) - \text{ir}}{1 + \text{ir}} \times \sum_{t=1}^{n} \left(\frac{1 + \text{ir}}{1 + r} \right)^t. \end{aligned} \tag{3.12}$$

We use for the discount rate r the yield on ten years government bonds plus a risk premium of 1% (5.57%), approximately the mortgage interest rate. Table 3.1 summarizes the input parameter for the user cost approach and provides the values that are used in the calculations. Table 3.2 provides an example of the user cost approach. The initial value is assumed to be €100,000. The marginal tax rate equals 41.4%. The user cost u^{10} equals 4.16%.

[7] Alternatively, we could have kept the debt D_t fixed in time. The capital gain ΔD_t is zero, except for the last period, being equal to $V_n - D_0$. This results in a slightly higher user cost $u^n = R_0/V_0$.

[8] This value was realistic in early 2008, the time that the calculations were performed. Currently, more realistic values of the value to income ratio are in the range 3.5 to 4.

Table 3.1: Parameters for the user cost approach.

Parameter	Description	Value
r	discount rate	5.57%
mt	marginal tax rate, depends on income $\approx V_0/4.5$	
d^*	maintenance, insurance and major repairs(as % of V_{t-1})	2.03%
tc	transaction costs (as % of V_0)	10%
n	average occupancy duration	10 years
tir	tax on inputed rent (as % of V_{t-1})	0.55%
pt	property tax (as % of V_{t-1})	0.10%
p	expected inflation	2.20%
r_V	expected yearly return on V_t, additional to p	0.50%

The discount rate r is the yield on ten years government bonds in July 2007 (source: Dutch Central Bank) plus a risk premium of 1%. The total figure for maintenance, insurance and major repairs d^* is based on the following. The cost of major repairs is estimated to be 0.83%, see Conijn (1995). The general costs and the maintenance costs for housing associations are respectively €280 and €1,524 per house. The average house value for housing associations is equal to €150,353. The maintenance and insurance costs as percentage of the value are 1.2% (source: Aedes Bedrijfstakinformatie, figures from 2006). The transaction costs (tc) consist of transfer tax (6%) and additional fees for mortgage providers, Land Registry, and notary. The tax on imputed rent is 0.55% for houses with a value higher than €75,000. The percentage is somewhat lower for cheaper houses (source: Ministry of Finance). The property tax percentage (pt) differs over municipalities. The average value in 2007 is about 0.10% (source: COELO).

Table 3.2: Example of the user cost approach.

Year	V_t	D_t	ΔD_t	cD_t	dV_{t-1}	tirV_{t-1}	ptV_{t-1}	CIF_t
0	100.0	110.0						
1	102.7	111.9	1.90	3.59	2.03	0.32	0.10	4.14
2	105.4	113.8	1.93	3.65	2.08	0.33	0.10	4.24
3	108.3	115.8	1.96	3.72	2.14	0.34	0.11	4.34
4	111.2	117.8	2.00	3.78	2.20	0.35	0.11	4.44
5	114.2	119.8	2.03	3.84	2.26	0.36	0.11	4.54
6	117.3	121.9	2.07	3.91	2.32	0.37	0.11	4.65
7	120.5	124.0	2.10	3.98	2.38	0.38	0.12	4.75
8	123.8	126.1	2.14	4.05	2.45	0.39	0.12	4.86
9	127.1	128.3	2.18	4.12	2.51	0.40	0.12	4.98
10	130.5	130.5	2.21	4.19	2.58	0.41	0.13	5.36

The cost of capital cD_t is given by $r(1-\text{mt})D_{t-1}$, where in this example mt=41.4%.
All values $\times 1,000$ €.

4 Data

Market rents have been calculated for all houses of the housing association “de Alliantie”. The association owns approximately 57,700 houses in 4 different regions in the western part of the Netherlands. For about 5,500 houses the tenant has changed in the period 2005–2007. We will refer to these rents as new rents. This is a subset of the total number of new rents in this period. Some rents are excluded, for example in case of specific income requirements and houses labeled for students or elderly. For the total stock of houses a number of characteristics is available, including:

- *address details*, including neighborhood;
- *assessed value* (per 1/1/2007);
- *current rent*;
- *maximum reasonable rent*: rent level depends on a house value rating system. This house value rating system controls for housing and neighborhood characteristics, but has no relation with market values in the owner-occupied sector;
- *house size in square meters*;
- *classification of house type*: ground-floor / upstairs flat, corner house, gallery flat, maisonette, block of flats with a common entrance hall, and row house,
- *number of rooms*.

For the new rents the following additional variables are available:

- *the new rent* (R);
- *transaction year* (t): the date of advertisement is between January 2005 and December 2007. Transaction years are measured from July 1 to June 30, following the practice of housing associations. July 1 is the date of the regular rent increase. This results in transaction years from 2004 to 2007.
- *the number of reactions* (Y): the number of people that showed interest in the house;
- *the acceptance* (A): number of rejections plus 1 who accepted the house.

Table 4.1 provides an overview of the total housing stock, the housing stock of “de Alliantie”, and the new rents. The city of Amsterdam has the smallest percentage of owner-occupied houses, 22.3%. The percentages of the other regions are close to the national average, being 55.2%. Flevoland has the lowest average value, followed by the city of Amsterdam. However, for the housing association stock Amsterdam has the highest average value (per square meter), closely followed by Gooi en Vecht. The average house size in Amsterdam is relatively small compared to other regions.

The yearly rent to value ratio for the total stock of the housing association is on average 2.9%, the lowest in the city of Amsterdam, and the highest in Flevoland. For the new rents this ratio is higher, on average 3.4%. It shows that the housing association increases the rent when there is a tenant change. The percentage difference between the actual rent and reasonable rent is lower for the new rents than for all houses. Note that for the city of Amsterdam for the new rents the actual rent level is equal to the maximum reasonable rent level.

The average assessed value of houses with new rents (€163,000) is somewhat lower than the average for the total housing stock of the housing association (€178,000). This also holds for the house size, 54.1 m^2 versus 58.0 m^2. The difference in the average value per square meter is even smaller, €3,077 versus €3,157. It can be concluded that the subsample of the new rents is representative for the total housing stock of the housing association.

For the total stock of the housing association the correlation between the rent level and the value is only 0.34, in logs it is even lower, 0.28. The new rents show more correlation between the rent level and the value, 0.61 and in logs 0.65.

Kernel densities of the log number of reactions and acceptances are estimated by the method proposed by Hansen (2005). The Tables 4.2 and 4.3 show respectively the quantiles from the kernel distributions of the log number of reactions and the acceptance for the year 2007. The kernel densities are given in Figures 4.1 and 4.2. The region ‘Gooi en Vecht’ has the largest number of reactions, a median value of 215.6. The median value in ‘Eemvallei’ is only 118.5. The 95% quantiles of the acceptance are used as the threshold values q_a for the calculation of the market rents. The threshold values differ over the regions, from 8.5 in Flevoland to 31.8 for Amsterdam. It is striking that the number of rejections in Amsterdam is much larger than the other regions. We do not have an explanation for this large difference.

Table 4.1: Summary of variables for the different regions.

	Region	Houses	OO	Value	Size	Value per m²	Rent	Reason	%Value
Total									
1	Amsterdam	387,531	22.3%	232					
2	Gooi en Vecht	108,303	56.0%	339					
3	Eemvallei	58,618	55.0%	248					
4	Flevoland	145,871	63.5%	199					
	Total	700,323							
Housing association									
1	Amsterdam	21,555		190	54,7	3,578	398	479	2.6%
2	Gooi en Vecht	13,496		189	59,1	3,244	431	585	2.8%
3	Eemvallei	16,102		167	59,6	2,858	416	591	3.1%
4	Flevoland	6,576		144	62,6	2,347	451	593	3.9%
	Total	57,729		178	58,0	3,157	417	548	2.9%
New rents									
1	Amsterdam	2,028		177	51,8	3,496	462	462	3.3%
2	Gooi en Vecht	1,006		170	53,4	3,196	423	537	3.1%
3	Eemvallei	1,574		155	55,6	2,838	446	555	3.5%
4	Flevoland	945		139	56,6	2,485	426	535	3.8%
	Total	5,553		163	54,1	3,077	443	520	3.4%

'Houses' provides the number of houses per region at January 2008.
'OO' means the percentage of owner-occupied houses in the region at January 2008.
'Value' is the average assessed value in €1,000, price level January 2007.
'Size' is the average house size in m^2.
'Rent' is the average current rent per month.
'Reason' is the average maximum monthly reasonable rent, set by the rent control system.
'%Value' is average of the yearly rent as percentage of the value.
The most important city in the region Eemvallei is Amersfoort.
The figures in the panel 'Total' are obtained from Statistics Netherlands.

Table 4.2: Quantiles of log reactions for different regions in 2007.

Quantile	Amsterdam	Gooi en Vecht	Eemvallei	Flevoland
0.05	3.874 (48.1)	4.084 (59.4)	3.466 (32.0)	2.779 (16.1)
0.10	4.215 (67.7)	4.505 (90.5)	3.773 (43.5)	3.224 (25.1)
0.25	4.504 (90.4)	4.922 (137.2)	4.105 (60.7)	4.100 (60.3)
0.50	4.783 (119.4)	5.373 (215.6)	4.411 (82.4)	4.775 (118.5)
0.75	5.091 (162.6)	5.775 (322.3)	4.685 (108.3)	5.292 (198.7)
0.90	5.485 (241.0)	6.068 (431.9)	4.910 (135.6)	5.696 (297.8)
0.95	5.760 (317.4)	6.214 (499.9)	5.036 (153.9)	5.910 (368.5)

Between parentheses the corresponding number of reactions are given.

Table 4.3: Quantiles of log acceptance for different regions in 2007.

Quantile	Amsterdam	Gooi en Vecht	Eemvallei	Flevoland
0.05	0.813 (2.3)	0.063 (1.1)	0.062 (1.1)	0.068 (1.1)
0.10	1.425 (4.2)	0.125 (1.1)	0.123 (1.1)	0.136 (1.1)
0.25	1.908 (6.7)	0.330 (1.4)	0.321 (1.4)	0.366 (1.4)
0.50	2.281 (9.8)	0.846 (2.3)	0.866 (2.4)	0.935 (2.5)
0.75	2.688 (14.7)	1.490 (4.4)	1.682 (5.4)	1.490 (4.4)
0.90	3.160 (23.6)	2.003 (7.4)	2.236 (9.4)	1.910 (6.8)
0.95	**3.460** (31.8)	**2.293** (9.9)	**2.565** (13.0)	**2.136** (8.5)

Between parentheses the corresponding acceptances are given.

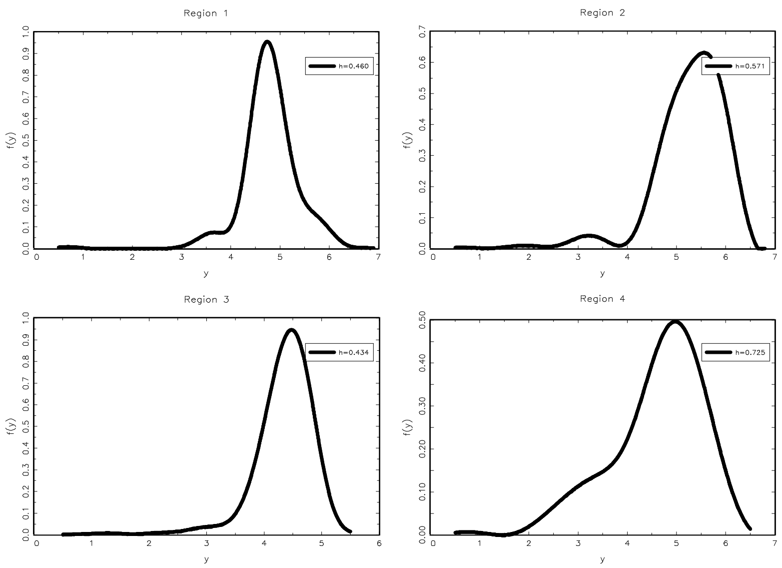

Figure 4.1: Kernel density of log reactions in different regions in 2007.

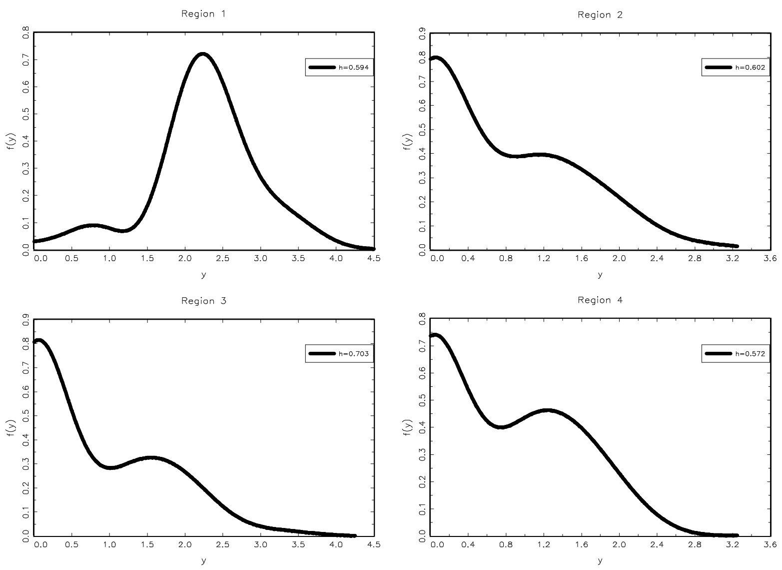

Figure 4.2: Kernel density of log acceptance in different regions in 2007.

5 Application

5.1 Estimation results from the reaction model

In this Section the reaction model is estimated on the data of the housing association “de Alliantie”. The log number of reactions (y_{ijt}) is modeled by

$$y_{ijt} = \alpha_j + \gamma_t + r_{ijt}\delta + v_{ijt}\theta + x'_{ijt}\beta + \varepsilon_{ijt}, \quad \varepsilon_{ijt} \sim N(0, \sigma^2), \tag{5.1}$$

where $\alpha_j \sim N(\mu, \tau^2\sigma^2)$ are random effects for neighborhoods ($j = 1, \ldots, J$), γ_t are fixed time effects ($t = 1, \ldots, T$), r_{ijt} is the log housing rent with coefficient δ, v_{ijt} is the log assessed house value with coefficient δ, and x_{ijt} is a vector of house characteristics with coefficient vector β.

The time index t is measured in years, where a year starts on the first of July, that is the date of a possible rent increase. The time effects γ_t are modeled by fixed effects. γ_1, that is for 2004, is assumed to be zero, avoiding the dummy trap. For the random effects an existing division in neighborhoods has been used.

The original market values have price level date 1/1/2007. These values are indexed (backwards or forwards) to the transaction date by a repeat sales index on a monthly basis. The index is computed on a detailed level, if possible on a house type and postal code level. If no price index is available on a detailed level, a less detailed level is used, for example a price index for a specific house type in a city. For a detailed description of the computation of the price index, see Francke (2009).

The random effects model can be seen as a special case of a hierarchical or multilevel model, see for example Bryk and Raudenbush (1992) and Goldstein (1995). Conditional on the scale parameter τ estimators of $\alpha, \gamma, \beta, \delta, \mu$ and σ^2 can be obtained analytically. The maximum likelihood estimator of τ can be obtained by maximizing the concentrated (with respect to $\alpha, \gamma, \beta, \delta, \mu$ and σ^2) likelihood. The estimation procedures have been written in GAUSS (Aptech Systems, Inc), using the maximum likelihood library.

The model is estimated separately for the different regions. Table 5.1 contains the estimation results. As expected the coefficients for the log rent (r) are negative and the coefficients for the log market value (v) and house size are positive. Dummy variables for the number of rooms are included. The omitted variable is the number of rooms equal to 3. Also different house types dummies are included in the regression. The omitted category is block of flats with a common entrance hall. From the time dummy variables it can be seen that there is a strong increase in the number of reactions over the years. The number of observations N varies between 945 and 2,028, and the number of neighborhoods J varies between 3 and 22. The standard error of the regression σ is large for all regions, about 0.5, specifically for region 4, 0.74. The adjusted R^2 varies between 0.518 and 0.598.

5.2 Market rents from the reaction model

From the estimation results presented in the preceding subsection market rents can be derived, using Eq. (2.6). For q_a we use the 95% quantiles of log acceptance in 2007 as provided in Table 4.3. Table 5.2 provides some quantiles of the redistribution effect, as given in Eq. (2.4), and Table 5.3 provides the level effect, as given by $-(q(y^*; \alpha) - q_a)/\delta$, both for the new rents in the 4 regions.

It can be concluded from Table 5.2 that the redistribution effect is the largest in the city of Amsterdam, and the smallest in the Gooi en Vecht region. In Amsterdam, for 5% of the new rents the log rent is reduced more than 0.350, and for 5% the rent is increased more than 0.373, without changing the average log rent level. These figures are for the Gooi en Vecht region 0.214 and 0.22, respectively. Table 5.3 shows that the largest level effect is in the Gooi en Vecht region (41.5%), followed by Amsterdam (26.6%). Note that for the new rents in Amsterdam the current rent equals the maximum reasonable rent (€462). In the Gooi en Vecht region the average current rent (€423) is much lower than the average maximum reasonable rent (€537), a difference of 26.9%, see Table 4.1. The rent increase above the average maximum reasonable rent is only 11.5% (1.1415/1.269-1), smaller than for the Amsterdam region.

Table 5.4 shows an overview of the market rents for 52,524 from the 57,729 houses of “de Alliantie”, more than 90%. For the remaining observations some of the necessary variables are missing. The averages of the calculated market rents are for all regions substantially higher than the actual rents. The average log

Table 5.1: Estimation results from the reaction model.

Variable	Amsterdam	Gooi en Vecht	Eemvallei	Flevoland
log(Rent)	-1.988 (0.090)	-5.106 (0.186)	-3.371 (0.118)	-6.021 (0.319)
log(Market Value)	0.634 (0.093)	1.028 (0.186)	0.899 (0.108)	0.137 (0.282)
log(House Size)	0.854 (0.114)	0.399 (0.179)		0.561 (0.290)
year 2005	-0.060 (0.029)	-0.057 (0.048)	-0.125 (0.073)	-0.036 (0.073)
year 2006	-0.000 (0.031)	0.130 (0.050)	0.101 (0.073)	0.076 (0.075)
year 2007	0.232 (0.042)	0.227 (0.062)	0.315 (0.076)	0.374 (0.086)
# Rooms$= 1$	-0.516 (0.056)			
# Rooms$= 2$	-0.250 (0.028)	-0.517 (0.057)	-0.573 (0.050)	-1.132 (0.107)
# Rooms$= 4$	0.086 (0.033)	0.292 (0.051)	0.027 (0.039)	0.228 (0.077)
# Rooms≥ 5	0.439 (0.057)	0.252 (0.069)	0.128 (0.054)	-0.080 (0.201)
ground-floor / upstairs flat	-0.023 (0.069)	-0.754 (0.181)	-0.181 (0.146)	-0.198 (0.093)
corner house		0.492 (0.088)		0.682 (0.122)
gallery flat	-0.406 (0.056)	0.274 (0.065)	0.048 (0.044)	0.034 (0.076)
maisonette		-0.124 (0.071)	0.554 (0.087)	-0.010 (0.128)
row house	0.600 (0.059)	0.394 (0.059)	0.389 (0.036)	0.528 (0.086)
σ	0.421	0.482	0.499	0.736
$\tau\sigma$	0.240	0.283	0.239	0.285
Adjusted R^2	0.518	0.598	0.522	0.556
N	2028	1006	1574	945
J	13	22	20	3

Between parentheses the standard deviations are provided.

Table 5.2: Quantiles of log redistribution effect for the new rents.

Quantile	Amsterdam	Gooi en Vecht	Eemvallei	Flevoland
0.05	-0.350	-0.214	-0.287	-0.295
0.10	-0.285	-0.157	-0.199	-0.197
0.25	-0.152	-0.056	-0.087	-0.063
0.50	0.003	0.013	0.013	0.026
0.75	0.141	0.074	0.102	0.095
0.90	0.279	0.127	0.176	0.150
0.95	0.373	0.159	0.223	0.180

Table 5.3: Level effect for the new rents.

	Amsterdam	Gooi en Vecht	Eemvallei	Flevoland
Level effect	+26.6%	+41,5%	+16.1%	+6,0%

difference between market rent and current rent is the highest for Amsterdam, 0.646, followed by Gooi en Vecht, 0.456. For the Flevoland region this is the lowest, 0.147. These figures are in line with expectations; the housing market in Amsterdam and Gooi en Vecht is tensed. The market in Flevoland is more relaxed. Flevoland is the only region where the average market rent is lower than the average maximum reasonable rent. For the Eemvallei region both rents are almost equal.

Table 5.4: Estimated rents from reaction model.

Region	MR*	MR	Reason	Current	Rel. Dif	MV	%MV	Number
Amsterdam	473	774	474	405	0.646	192,176	4.84	19,606
Gooi en Vecht	574	671	585	431	0.456	188,517	4.43	13,091
Eemvallei	555	581	582	410	0.364	164,480	4.31	13,520
Flevoland	522	525	595	455	0.147	145,472	4.40	6,307
Total	525	669	544	419	0.466	178,527	4.54	52,524

‘MR’ is the average monthly market rent from the reaction model.
‘Reason’ is the average monthly maximum reasonable rent, set by the rent control system.
‘Current’ is the average monthly current rent.
‘MR*’ is the minimum of ‘MR’ and ‘Reason’.
‘Rel. Dif.’ is the average log difference between the market rent and the current rent.
‘MV’ is the assessed property value.
‘%MV’is the yearly market rent as a percentage of the assessed property value.

Table 5.5: Comparison of reaction model and user approach.

Region	Reaction	User Cost	Rel. Dif	sd. Rel. Dif	Number
Amsterdam	774	745	0.027	0.179	19,606
Gooi en Vecht	671	680	0.010	0.160	13,091
Eemvallei	581	599	-0.022	0.118	13,520
Flevoland	525	518	0.019	0.133	6,307
Total	669	664	0.009	0.156	52,524

‘Reaction’ is the average monthly market rent from the reaction model.
‘User Cost’ is the average monthly market rent from the user cost approach.
‘Rel. Dif.’ is the average log difference between ‘Reaction’ and ‘User Cost’.
‘sd. Rel. Dif.’ is the standard deviation from the log difference between ‘Reaction’ and ‘User Cost’.

5.3 Comparison of market rents

Table 5.5 provides a comparison of the market rents calculated from the user cost approach and the reaction model for all houses of the housing association “de Alliantie”. The average market rents from both models are remarkably close to each other. For the total housing stock of “de Alliantie” the average rent from the reaction model is €669, whereas the average rent from the user cost approach is €664, a difference of less than 1%, notwithstanding the different methods applied. The averages of the log differences between both market rents are also relatively small, varying between -2.2% in the Eemvallei and +2.7% in Amsterdam. Their standard deviations differ from 11.8% in Eemvallei to 17.9% in Amsterdam. Figure 5.1 provides a histogram of the ratio between the market rent from the reaction model and the user cost approach for the total housing stock of “de Alliantie”. Most of these ratios (about 90%) lie between 0.75 and 1.25.

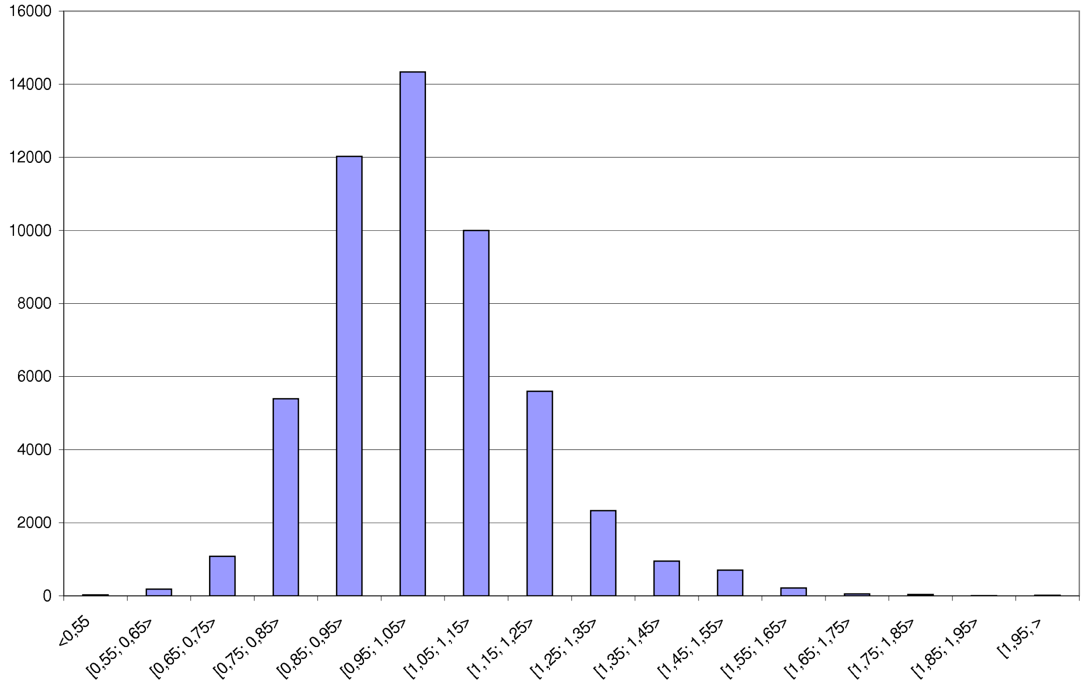

Figure 5.1: Histogram of ratio of market rent by the reaction model and user cost approach.

6 Conclusions

In this paper two different methods have been applied to calculate market rents, namely the user cost approach and the reaction model. In the reaction model demand side information from the tenants, the number of persons interested in a house for a given rent and quality of the house, is used to derive market rents. On the other hand the user cost approach heavily relies on assessed values, using transaction information from the owner-occupied sector. Both methods have been applied to houses from a housing association in the Netherlands. On average the outcomes of these models have a close resemblance, although relying on different assumptions and information. On an individual basis the market rents from both methods differ, however the standard deviation of the relative differences is modest.

In the reaction model two effects are distinguished, a redistribution effect and a level effect. The redistribution effect depends on the specification of the regression model that explains the number of reactions by the rent level, the assessed value and other characteristics. The redistribution effect for the rents are calculated from the estimation results from the regression model, leaving the average rent level constant. The level effect shifts the average rent level. The size of this level shift depends on the α-quantile of the number of reactions. It must be larger than some threshold, derived from the $1-\alpha$-quantile of the acceptance. Changing the value of α from 5% to 1% will have an impact on the level effect. The choice of $\alpha = 0.05$ leads to market rents that are close to those derived from the user cost approach.

Sensitivity analysis, including varying quantiles, different regression model specifications and different parameter assumptions in the user cost model, is left for further research.

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